Environmental Guideline for the

Management of Contaminated Sites

Department of Environment
Government of Nunavut

GUIDELINE: MANAGEMENT OF CONTAMINATED SITES

Originally Approved	April 1999
Revised	January 2002 March 2009 December 2014

This Guideline has been prepared by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment under authority of the *Environmental Protection Act.*

This Guideline is not an official statement of the law and is provided for guidance only. It is intended to provide general guidance on assessment and remediation of contaminated sites and assist in their management. This Guideline does not replace the need for the land owner, site operator or person in charge, management or control of the contaminated site to comply with all applicable legislation and consult with Nunavut's Department of Environment, other regulatory authorities and qualified persons with expertise in the management of contaminated sites.

Copies of this Guideline are available upon request from:

Department of Environment
Government of Nunavut
P.O. Box 1000, Station 1360, Iqaluit, NU, X0A 0H0
Electronic version of this Guideline is available at http://www.gov.nu.ca/env/environment

Cover Photos: Government of Nunavut Department of Environment

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Introduction

A contaminated site is broadly defined as a location at which levels of contaminants in soil, water or sediment pose an unacceptable risk to the health and safety of people and the environment. Management of a contaminated site refers to the process of identifying, characterizing and remediating, or cleaning up, the site.

Most contaminated sites in Nunavut are the result of petroleum hydrocarbon spills (i.e. gasoline, jet fuel, diesel, bunker fuel). For this reason, the *Environmental Guideline for the Management of Contaminated Sites* (the Guideline) focuses on the management of petroleum hydrocarbon (PHC) contaminated soil, water and sediment. Where sites are contaminated with other substances or chemicals, the principles and methods described in this Guideline may still be applied.

PHC contamination is a concern for several reasons. To differing degrees, PHCs are toxic to plants and animals, and are mobile and persistent in the environment. They can also pose a fire or explosion hazard and create aesthetic problems such as unsightly land, offensive odours and bad tastes. In some cases the concern may also be financial, because of the loss of property value and significant cost of remediating the property.

The intent of this Guideline is to assist land owners and site operators establish a consistent approach to managing contaminated sites in Nunavut. It provides a general step-by-step overview of the process. This includes the identification and characterization (i.e. assessment) of the site, determination of site-specific remediation criteria using a guideline-based or risk-based approach, a general overview of remediation methods and technologies, development and implementation of a Remedial Action Plan, site closure and the identification of long-term monitoring requirements.

The *Environmental Protection Act* enables the Government of Nunavut to implement measures to preserve, protect and enhance the quality of the natural environment. Section 2.2 of the *Act* provides the Minister of Environment with authority to develop, coordinate, and administer this Guideline.

1.1 Definitions

CCME	The Canadian Council of Ministers of the Environment (CCME) is the major federal, provincial and territorial forum for discussion and joint action on environmental issues of national, international and global concern. The 14 member governments work as partners in developing nationally consistent environmental standards and practices.
Closure Report	The report prepared following implementation of the Remedial Action Plan and generally includes a description of all site activities, quantity of contaminated material treated or removed from site, the treatment and disposal methods used, and all analytical testing data.
Commissioner's Land	Lands that have been transferred from the Government of Canada by Order-in-Council to the Government of Nunavut. This includes roadways and land subject to block land transfers. Most Commissioner's Land is located within municipalities.

Contaminant	Any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment, (a) endangers the health, safety or welfare of persons, (b) interferes or is likely to interfere with normal enjoyment of life or property, (c) endangers the health of animal life, or (d) causes or is likely to cause damage to plant life or to property.
Contaminated Site	Areas of soil or gravel, surface water, groundwater or sediments that have levels of contaminants that exceed the remediation criteria. Contaminant sources can include the on-site burial of wastes, small or frequent drips and spills, stockpiling and storage of hazardous materials, major spills and releases during fires. Contamination may also be caused by the illegal dumping of contaminated soil. Contaminated sites may have short or long term consequences to the health and safety of people and the quality of the environment.
Discharge	Includes any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling or escaping.
Environment	Means the components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c) above.
Environmental Quality Guideline	A generic numerical limit or narrative statement that has been established to maintain and protect a specified use of water, sediment or soil without taking into account site-specific conditions.
Inspector	Means a person appointed under subsection 3(2) of the *Environmental Protection Act* and includes the Chief Environmental Protection Officer.
Petroleum Hydrocarbons	A mixture of organic compounds found in and derived from oil, bitumen and coal. Petroleum products typically contain thousands of compounds in varying proportions, composed predominantly of carbon and hydrogen, with minor amounts of nitrogen, sulphur and oxygen.
Phase I Environmental Site Assessment	The process, as outlined in the Canadian Standards Association (CSA) Standard Z768, by which a qualified person determines whether a property is, or may be, contaminated.
Phase II Environmental Site Assessment	The process, as outlined in the CSA Standard Z769, by which a qualified person characterizes and delineates concentrations and quantities of contaminants on a site and compares those levels to acceptable environmental quality standards and objectives.

Qualified Person	A person who has an appropriate level of knowledge and experience in all aspects of contaminated site management.
Remedial Action Plan	A plan that outlines the preferred approach to decommissioning and cleaning up the contaminated site. The plan identifies the site-specific remedial objectives to be achieved, identifies remediation options and outlines their feasibility, and provides site-specific remediation criteria, a performance monitoring plan, and, if appropriate, requirements for long-term site management.
Remediation	The process of restoring a site's environmental condition and reducing any existing hazards to human health and safety to an acceptable level. Remediation involves the development and application of an approach that removes, destroys, contains or otherwise reduces the availability of contaminants to people and the environment.
Remediation Criteria	Numerical limits or narrative statements pertaining to individual substances or chemicals in soil, water or sediment which have been adopted for a specific site after taking into consideration the presence, concentration and nature of the contamination and relevant site conditions.
Responsible Party	The owner or person in charge, management or control of the contaminant before it is discharged or the owner of the contaminated site.
Transport Authority	The statute and regulations controlling the management of hazardous waste under that mode of transport. These include: (a) Road and Rail - *Transportation of Dangerous Goods Act* (Canada) and *Regulations; Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*. (b) Air - *International Air Transport Association (IATA) Dangerous Goods Regulations* and *International Civil Aviation Organization* (ICAO) *Technical Instructions;* and (c) Marine - *International Maritime Dangerous Goods Code* (IMDG).

Additional definitions of key terms are located in Appendix 2.

1.2 Roles and Responsibilities

1.2.1 Land Owners and Site Operators

A land owner or site operator who becomes aware, or otherwise has reason to believe, a site is contaminated must immediately take measures to manage the contamination and prevent or minimize impacts to humans and the environment. Immediately upon stopping or controlling any ongoing spillage or discharge and ensuring the safety of workers and any affected members of the public, the owner or operator must without delay report the spill to the NWT/Nunavut 24-Hour Spill Report Line at 867-920-8130 in accordance with the *Spill Contingency Planning and Reporting Regulations*. Once these

initial measures have been undertaken, the owner or operator is required to assess the presence and extent of contamination and develop and implement a Remedial Action Plan.

Contractors may manage contaminated sites on behalf of the land owner and site operator. However, the owner and operator remain responsible for ensuring the management actions comply fully with all applicable statutes, regulations, standards, guidelines and community by-laws. If the contractor does not comply with the requirements of the *Environmental Protection Act* and is charged with a violation while managing the contaminated site, the owner and operator may also be charged.

1.2.2 Government of Nunavut

Department of Environment

The Environmental Protection Division is the key environmental agency responsible for ensuring the proper management of contaminated sites on Commissioner's Land. Key responsibilities include confirming the required level of remediation using remediation criteria cited in this document, reviewing the proposed Remedial Action Plan submitted by the land owner or site operator, monitoring the progress of the remediation project and issuing a letter of confirmation when no further remedial action is required.

Authority is derived from the *Environmental Protection Act*, which prohibits the discharge of contaminants to the environment and enables the Minister of Environment to undertake actions to ensure appropriate management measures are in place. Although programs and services are applied primarily to activities taking place on Commissioner's and community lands and to Government of Nunavut undertakings, the *Environmental Protection Act* may be applied to the whole of the territory where other controlling legislation, standards and guidelines do not exist. A complete listing of relevant legislation and guidelines can be obtained by contacting the Department of Environment or by visiting the web site at http://env.gov.nu.ca/programareas/environmentprotection.

Workers' Safety and Compensation Commission

The Workers' Safety and Compensation Commission is responsible for promoting and regulating worker and workplace health and safety in Nunavut. The Commission derives its authority from the *Workers' Compensation Act* and *Safety Act* which require an employer to maintain a safe workplace and ensure the safety and well being of workers. The Workplace Hazardous Materials Information System, or WHMIS, requires that information be provided to workers on the safe use of any hazardous material used in the workplace.

Department of Community and Government Services

The Department of Community and Government Services is responsible under the *Commissioner's Lands Act* for issuing land leases, reserves, licenses and permits on Commissioner's Lands. The Department, in cooperation with community governments, is also responsible for planning and funding solid waste and sewage disposal facilities in most Nunavut communities. The Department's emergency planning responsibilities under the *Emergency Measures Act* include developing territorial emergency response plans, coordinating emergency operations at the territorial and regional levels and supporting community emergency response operations.

The Office of the Fire Marshal is responsible for ensuring the safe storage, handling and use of flammable and combustible liquids and the removal of fuel storage tanks from active service. The Office of the Fire Marshal derives its authority from the *Fire Prevention Act*, National Fire Code and National Building Code.

Department of Health

Contaminated sites may impact adjacent properties, residences or other buildings and affect the health and safety of the public. The Office of the Chief Medical Officer of Health and Regional Environmental Health Officers should be consulted regarding any legislated requirements under the *Public Health Act*.

Department of Economic Development and Transportation

The Motor Vehicles Division is responsible for ensuring the safe transport of contaminated soil and other hazardous waste by road through administration of the *Transportation of Dangerous Goods Act*. The Department is also responsible under the *Motor Vehicles Act* for driver licensing and various other vehicle and road safety matters.

1.2.3 Government of Canada

Environment Canada

Environment Canada and Health Canada are responsible for administering the *Canadian Environmental Protection Act* including the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations*. Environment Canada is also responsible for regulating the interprovincial and international movement of hazardous waste through the *Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* and for administering the pollution prevention provisions of the federal *Fisheries Act*.

Aboriginal Affairs and Northern Development Canada

Aboriginal Affairs and Northern Development Canada is responsible under the *Territorial Lands Act* and *Nunavut Waters and Nunavut Surface Rights Tribunal Act* for the management of federal lands and inland waters in Nunavut, including the impact contaminated sites may have on the quality of these lands and waters.

1.2.4 Community Governments, Designated Inuit Organizations and Co-Management Boards

Local Community Governments

Community governments are key participants in the proper local management of waste from contaminated sites. Under the Nunavut Land Claims Agreement, communities are entitled to control their own solid waste and sewage treatment facilities. Waste from contaminated sites may be deposited or treated at community waste facilities only with the consent of the local government. The local fire department may also be called upon if a fire or other public safety issue is identified.

Designated Inuit Organizations

The administration of land-related matters on Inuit Owned Land is the responsibility of the Qikiqtani Inuit Association (Baffin), Kivalliq Inuit Association (Keewatin) and Kitikmeot Inuit Association (Kitikmeot). Authorization is required in order to access and occupy Inuit Owned Land for the purposes of any private, commercial or public nature; mining or quarrying; or residential or recreational use. The regional land administration organization is responsible for issuing licenses and land leases, inspecting all activities authorized under a license or lease, and enforcing regulations related to use of these lands.

Co-management Boards and Agencies

Co-management boards and agencies established under the Nunavut Land Claims Agreement have broad authority for land use planning, impact assessment and the administration of land and water. Activities involved in the management of contaminated sites may be controlled through setting terms and conditions in plans, permits and licenses issued by the Nunavut Planning Commission, Nunavut Impact Review Board and Nunavut Water Board.

1.3 Key Government Policy Considerations

Public concern over contaminated sites has increased in recent years. As a result, national, federal and territorial policy has been developed to keep pace with the complex issues and emerging technologies associated with the management of these sites. This section outlines the key policy considerations that have emerged in response to the contaminated sites issue.

1.3.1 Protection of the Environment and Human Health

Government policy related to the management of contaminated sites recognizes the equal protection of human health and the environment. Inherent in this philosophy is recognition that the environment, upon which all human health depends, should not be viewed as being secondary but is deserving of protection for its own sake.

1.3.2 Responsibility and Liability

The issue of identifying who is responsible for a contaminated site and liable for any subsequent costs is sometimes complex and difficult. Where a land owner or site operator is responsible for the contamination, the 'polluter pays' principle suggests those responsible for causing the pollution are accountable for the costs associated with remediating any damages. However, the allocation of responsibility becomes more difficult where the site has been abandoned, ownership has changed, sites are owned by persons innocent of contaminating the land or when sites are controlled or owned by persons who cannot afford the costs associated with its remediation. In these cases, the principles of 'fairness' (certainty of process, effectiveness, efficiency, clarity, consistency and timeliness in achieving environmental objectives), 'beneficiary pays' (those who benefit from the remediation should contribute to the costs) and 'openness, accessibility and participation' (the public has an opportunity to provide input) help to form the basis of the decision around responsibility and liability.

1.3.3 A Shift to Prevention

The focus has shifted from clean up and remediation to the prevention of pollution. Under the *Spill Contingency Planning and Reporting Regulations*, owners or persons in charge, management or control of contaminants are required to prepare spill contingency plans designed to control or prevent conditions that could lead to contamination.

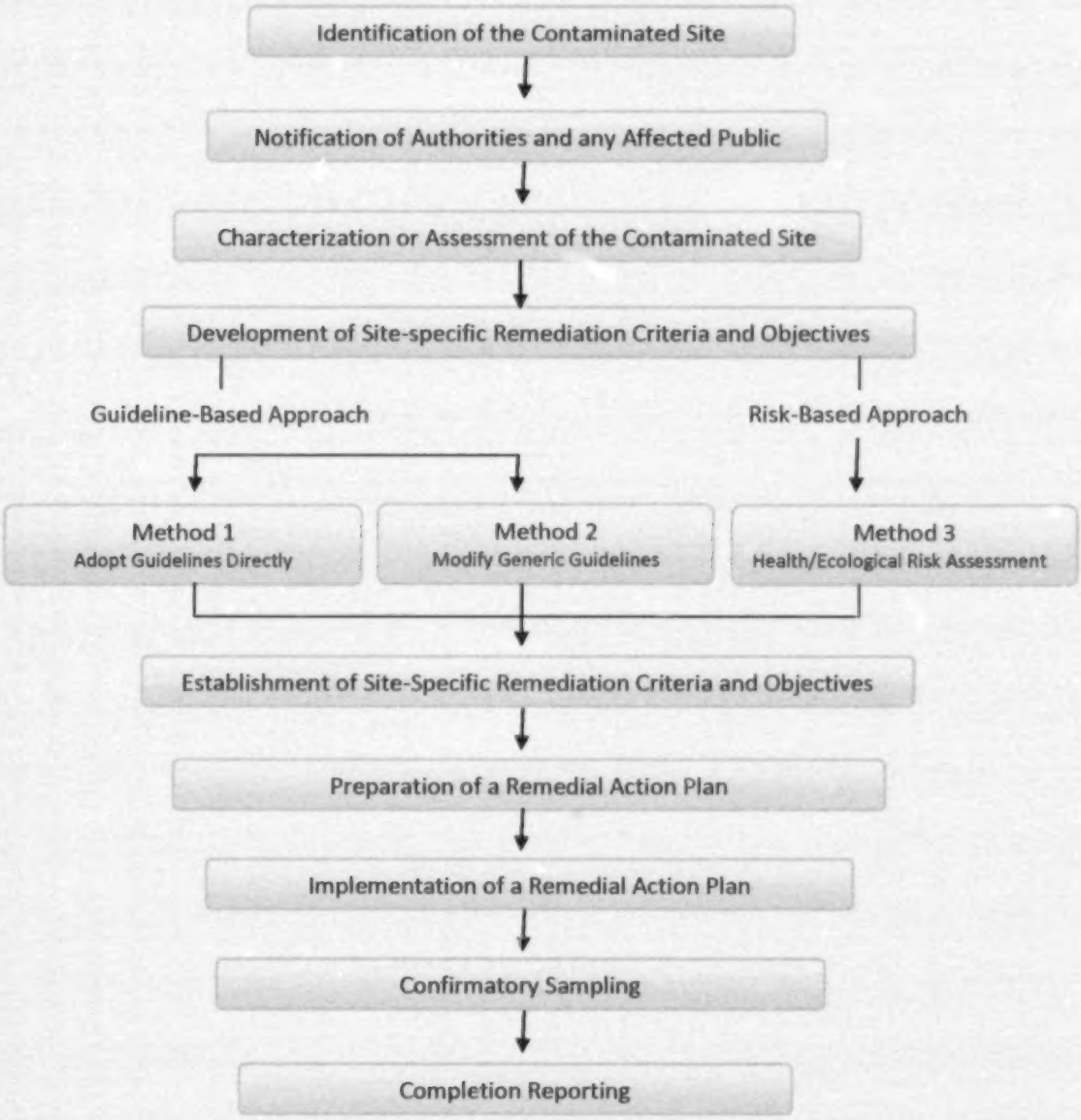
1.3.4 Remediation Based on Intended Land Use

The development of environmental quality standards and objectives has been undertaken in Canada within the context of specific land uses. In Nunavut, the designated categories of land use are based upon the protection of key human and ecological receptors, from most sensitive to least sensitive. These are: agricultural, wildland, residential, parkland, commercial and industrial. It is important to note that it is the *current and intended future land use* that governs the decision on what level of remediation is performed at a contaminated site.

Steps for Managing a Contaminated Site

The management of a contaminated site consists of a stepped approach. These steps address the identification of the site, notification of authorities, characterization, development and acceptance of site-specific remediation objectives and criteria, preparation and implementation of a Remedial Action Plan, confirmation that the remediation objectives and criteria have been achieved and completion reporting. A well considered and comprehensive approach enables the land owner and site operator to make informed decisions, which result in the safe, effective and cost-efficient management of the site.

The following diagram summarizes the general steps in the management process.


Identification of the Contaminated Site
Notification of Authorities and any Affected Public
Characterization or Assessment of the Contaminated Site
Development of Site-specific Remediation Criteria and Objectives
Guideline-Based Approach
Risk-Based Approach
Method 1
Adopt Guidelines Directly
Method 2
Modify Generic Guidelines
Method 3
Health/Ecological Risk Assessment
Establishment of Site-Specific Remediation Criteria and Objectives
Preparation of a Remedial Action Plan
Implementation of a Remedial Action Plan
Confirmatory Sampling
Completion Reporting

Each contaminated site is unique. As a result, different approaches and techniques may be required in order to manage the site in the most efficient and effective manner. As an example, at some sites it may be necessary to complete all stages of information gathering before making a final management decision while at other sites sufficient information may already be available or more than one stage may be combined to make the planning more efficient.

2.1 Identification of Potentially Contaminated Sites

There are many ways to identify a potentially contaminated site. The most obvious is by the first-hand observation of a spill or discharge. Other ways include reviewing existing environmental records (i.e. reports from the NWT/Nunavut 24-Hour Spill Report Line, historical environmental investigations and site assessments), complaints from the public, the presence of visual evidence (i.e. stained soil, stressed vegetation) and odours from previous spills or discharges, observation of off-site impacts, similarities with other known contaminated sites, the nature of current or past activities at the site or as a result of earlier investigations completed for the redevelopment, sale or refinancing of a property.

2.2 Initial Notification

Where a person discovers the presence of contamination they should immediately notify regulatory authorities and the owner of the facility or property. Section 5.1 of the *Environmental Protection Act* states that where a discharge occurs, or is likely to occur, the owner or person in charge, management or control of the contaminant must immediately:

- report the discharge to the NWT/Nunavut 24-Hour Spill Report Line at (867) 920-8130;
- take all reasonable measures to safely stop the discharge and repair damages; and
- make reasonable efforts to notify any affected public.

Once regulatory authorities have been notified, the significance of the contamination will be assessed by an Inspector conducting a site visit or by reviewing other relevant information (i.e. previous site assessment reports). Where it is determined that contamination poses a risk to human health, safety or the environment, the land owner or site operator must immediately initiate actions to protect the public and clean up and repair any environmental damages that may have occurred.

Where the environmental damage cannot be adequately addressed through limited remedial actions, the owner or operator may be instructed to obtain the services of a qualified person (i.e. environmental engineer or consultant). Obtaining the services of a qualified person in a timely manner is recommended where there is evidence of groundwater contamination, explosive vapours are present, or a neighbouring property has been affected. In all cases, the responsible party or its representative must consult the appropriate regulatory agencies and notify affected members of the public. The Department of Environment may require the owner or operator to provide proof of such consultation and notification.

Issues not related to public health, safety or the environment that arise between the responsible party and other parties are civil matters, and are to be settled by the parties outside of this management process.

2.3 Site Information Assessment: Phase I Environmental Site Assessment

Assessing, or characterizing, a potentially contaminated site is a critical stage in the site management process. A well-planned and comprehensive assessment will enable the land owner or site operator to make better informed decisions about the need for remedial actions.

An Environmental Site Assessment (ESA) is designed to identify the nature and extent of contamination on a site. A phased approach is usually undertaken, leading from the general to the specific, to ensure the most efficient use of personnel and resources. There can be up to three phases to an ESA, with each phase depending on the size and complexity of the contaminated site. While there are advantages to this approach, there may also be economies realized by combining information gathering and testing phases into a single investigation, particularly at remote locations where travel and mobilization costs are significant.

The objective of a Phase I ESA, also known as a site information assessment, is to assemble historical and current information to determine the likelihood of contamination existing at a site and help to develop a field-testing program, should one be required. The Phase I ESA must in all cases meet or exceed the Canadian Standards Association (CSA) Standard Z768-01, *Phase I Environmental Site Assessment*.

Information may be available from a variety of sources. Reports and documents that have previously been prepared for legal, real estate transactional or environmental purposes are common and should be reviewed. These include environmental baseline and previous site investigation reports; aerial photographs; geology and groundwater reports; topographical, geological and other maps; regulatory agency reports including spill incident reports[1]; company records and site plans and drawings.

The initial review should also include a visual inspection of the site and discussions with personnel and local residents who have knowledge of the site and its history. The inspection may identify visual signs of contamination (i.e. discoloured soil or building foundation walls), odours and vegetation stress and should examine local sensitive habitats (i.e. wetlands, beaches, ponds, streams) for the presence of contaminants. The proximity of the site to surrounding buildings, including residences, and sensitive habitats should also be noted.

Phase 1 - The initial actions undertaken to determine whether a property is, or is not, contaminated. A Phase I site information assessment involves reviewing all available reports, studies and other relevant documents on a site, but does not involve sampling, analysis and measurement of soil and water.

Phase II - Builds upon results of the Phase 1 assessment by sampling soil and water, and sometimes air, on a site to characterize and delineate the concentration of contaminants, and compare those levels to approved remediation criteria. A Remedial Action Plan may be developed following the Phase II reconnaissance testing program if all necessary information about the site has been obtained.

Phase III - The most detailed level of assessment that is intended to address any outstanding issues and information gaps following a Phase II assessment.

[1] The Government of the Northwest Territories maintains a database of hazardous material spills reported in the NWT and Nunavut since 1973. The database is available to the public by contacting the NWT Department of Environment and Natural Resources at 867-873-7654 or online at http://www.enr.gov.nt.ca/programs/hazardous-materials-spills/hazardous-materials-spill-database.

The work frequently includes three broad aspects:

Facility Characteristics	A current and historical description of the site and its facilities is developed, particularly as it relates to contaminant storage and areas where discharges may have occurred. Reviewing facility records and discussions with past and present personnel is an excellent way of gathering relevant information about the facility. Additional information can be obtained by reviewing blueprints and engineered drawings of the above and below ground structures as well as considering previous site and surrounding land uses.
Contaminant Characteristics	Petroleum hydrocarbons, chemicals and other contaminants that are present or may have previously been stored at the site are identified. Their quantities and concentrations can be estimated by visual inspections, reviewing available documentation and interviewing past and present personnel.
Physical Characteristics of the Site	The geology, hydrology and hydrogeology of the site and surrounding area are examined using available reports. The objective is to develop a comprehensive understanding of local site characteristics and a current and historical description of the area.

The accumulated information is then used to determine whether additional site investigation is required. Where further investigation is warranted, the information is used to develop a reconnaissance testing program, also known as a Phase II Environmental Site Assessment.

2.4 Reconnaissance Testing Program: Phase II Environmental Site Assessment

The objective of the Phase II ESA is to characterize the physical site conditions and any contaminants that may be present so an effective Remedial Action Plan can be developed. The Phase II ESA must in all cases meet or exceed the CSA Standard Z769-00, *Phase II Environmental Site Assessment*.

Characterization of the contamination and site conditions require an initial on-site testing program. The testing program enables a qualified person to confirm the presence and concentration of contaminants and provides an understanding of the nature of the contamination (i.e. location, quantity and direction of movement) and relevant site conditions (i.e. soil type, groundwater flow, exposure pathways). The testing may also confirm that no further investigation is required or identify the need to develop a more detailed Phase III ESA. Remediation criteria will also need to be selected during the Phase II ESA. This process is further described in section 2.7 *Establishment of Site-Specific Remediation Criteria and Objectives*.

Because conditions at any given site can be variable and complex (i.e. type of soil, grain size, depth of permafrost), all reasonable efforts must be made to ensure the testing provides a true representation of the site. Testing methods must be consistent with current professional standards and should include the adoption of recognized sampling procedures, quality assurance/quality control procedures and laboratory analytical protocols.

2.4.1 Field Screening Techniques

The reconnaissance testing program usually begins with field-screening. Screening techniques help to rapidly orient the investigation by identifying the need and location for more intrusive testing and analysis.

There are a variety of field screening techniques that can be used. Terrain conductivity using electro-magnetic surveys is a common geophysical technique used to identify buried drums and tanks, along with conductivity anomalies caused by some contaminants. Photoionization and explosive gas detection are techniques used to confirm the presence of contamination by measuring the level of PHC and other volatile gases in soils. A range of other field techniques is also available for detecting contaminants in soil and groundwater including portable gas chromatography, field atomic absorption and field x-ray fluorescence. Field screening instruments must be capable of calibrating measurements to relative or absolute levels of contamination, be verifiable in regard to procedures and results and the results correlated to Canadian Association for Environmental Analytical Laboratories (CAEAL) accredited laboratory results.

2.4.2 Intrusive Sampling Program

Once potential target areas have been identified by field screening, a more intrusive sampling program should be undertaken to obtain more definitive information about the nature and extent of the contamination and potential migration pathways. This program normally includes obtaining samples from affected soil, water and sediment for laboratory analysis.

The following are considered minimum requirements for any sampling program:

Soil — 3-5 boreholes or test pits are required for each potential source area, except very small sites where a minimum of 1 borehole or test pit is sufficient. Potential source areas include storage tanks and barrels, lines, pump islands, loading areas, previous underground installations and areas of discoloured or stained soil.[2] All test holes should extend to the bottom of the contaminated soil zone or to an impermeable layer (i.e. permafrost, bedrock), whichever is encountered first. All boreholes and test pits should be monitored for the presence of free product.

Groundwater — Sufficient test locations are required to determine the direction of groundwater flow. This normally includes a minimum of 3 groundwater monitoring wells or piezometers, including at least 1 multilevel installation to assess vertical gradients. Shallow wells should be screened to intercept floating or free phase product.

Quality Control — At least 1 'control location' is required to determine accurate background concentrations of the suspected contaminant. Each sample and control location should be marked or documented so it can be found again, if needed.

[2] This would equate to a minimum of 4 source test locations at a typical community POL facility with 1 tank nest, 1 set of lines, 1 pump island, and 1 waste oil tank.

2.4.3 Chemical and Physical Analysis

Analysis is to be conducted on at least 2 soil samples from each test hole (i.e. one surface <1.5 m depth, one subsurface >1.5 m depth) and at least one groundwater sample from each monitoring well. Grain size analysis is to be conducted on at least 1 sample per hydrogeologic unit if soil grain size criteria are to be applied.

Determining what contaminants to analyze for can be difficult. Chemical analysis should include the range of possible contaminants identified during the site information assessment and field screening stages. Alternatively, analysis for the range of contaminants that could reasonably be expected to be found based on what substances are normally stored on site, current site activities or past land use should be undertaken. Analyses for petroleum hydrocarbon impacted sites are always to include PHC and BTEX (benzene, toluene, ethylbenzene, xylene)[3].

For small batches of soil samples (i.e. less than 10 samples), at least one blind duplicate should be analyzed for each batch of samples. For larger batches (i.e. greater than 10 samples), 10% duplicates should be analyzed. For groundwater samples, a blind duplicate and field blank sample should be collected and analyzed for each batch of samples tested. The Quality Assurance/Quality Control (QA/QC) results should be presented and interpreted in the final closure report.

All sampling, sample handling and chemical analysis must be consistent with accepted practices. In particular, samples for volatile organics must be collected so that a minimum headspace in soil samples and no headspace in water samples is maintained. Samples should be kept cool, but not frozen, at all times until they are delivered to the laboratory. Sample handling procedures should be verified with the receiving laboratory and chemical analysis for petroleum hydrocarbons should be consistent with the CCME *Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil – Tier 1 Method (CCME, 2001)*.

Chemical analyses must be conducted by laboratories that have been formally recognized as competent to perform specified tests by the Canadian Association for Environmental Analytical Laboratories (CAEAL).[4]

Additional guidance on designing sampling programs and analyzing contaminants can be obtained by referring to the CCME *Guidance Manual on Sampling, Analysis and Data Management, Volume 1: Main Report and Volume 2: Analytical Summaries (1993)*.

2.5 Detailed Testing Program: Phase III Environmental Site Assessment

The results of the Phase II ESA will determine whether a Phase III ESA is required. If sufficient data has previously been obtained to characterize the site and any potential risk to human health, safety and the environment, then the process may move directly to final selection of site-specific remediation criteria and developing a Remedial Action Plan.

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[3] Soils with high natural organic carbon (such as peats) may give a "false positive" result when analyzed. If this is suspected, it may be beneficial to collect additional background soil samples for organic carbon analysis.

[4] CAEAL is a non-profit organization dedicated to raising the level of competency, consistency, capability, and communication within environmental testing laboratories in Canada. Their member laboratories voluntarily participate in rigorous programs of proficiency testing and accreditation, demonstrating their commitment to generate high quality and consistent data.

Alternatively, a detailed Phase III ESA may be necessary if Phase II testing indicates that significant and wide-spread contamination or information gaps exist. A Phase III ESA is intended to address any remaining outstanding issues and may include:

- targeting and delineating the boundaries of identified contamination;
- defining physical site conditions and possible contaminant pathways in greater detail, particularly with respect to possible risk assessment;
- providing contaminant and other information necessary to finalize the selection of remediation criteria or other suitable risk assessment approach; and
- providing all other information that is required in order to develop a Remedial Action Plan and prepare contract specifications and tender documents.

The Phase III detailed testing program will focus on areas identified in the Phase II program and involves a similar systematic approach to sampling, analysis and evaluation. However, a greater number of samples are usually collected and a smaller suite of chemical substances may be analyzed as the program converges on the outstanding environmental issues. Field screening techniques are not usually employed in this testing.

2.6 Environmental Quality Standards and Guidelines

Once the nature, extent and quantity of contamination at a site has been characterized, environmental quality standards and guidelines may be used to establish site-specific remediation criteria and objectives. A number of standards and guidelines for soil, water and sediment quality have been established in Canada. These may be adopted *de facto* as the site-specific remediation criteria and incorporated directly into the Remedial Action Plan or modified within certain limits.

The potential for exposure to a contaminant, the nature of the contaminant and soil texture are at the heart of many environmental quality standards and guidelines. Sections 2.6.1 through 2.6.3 explain these key factors and how they are used in the application of standards and guidelines.

2.6.1 Land Use

Numerical standards and guidelines are based on the level of risk a contaminant poses to humans, plants and wildlife. Human and ecological exposure and risk is largely influenced by the type of activities taking place on the land, or in other words, the specific land use. The generally accepted categories of land uses in Nunavut, from most sensitive to least sensitive, include:

Agricultural/Wildland	Land on which the primary activity is related to the productive capability of the land and includes lands that provide habitat for wildlife and birds.
Residential/Parkland	Land on which permanent, temporary or seasonal dwelling is the primary activity. Institutions (i.e. hospitals, schools, daycares), playgrounds and other activity areas that are recreational in nature are included under this land use. Residential/Parkland lands are normally readily accessible to the public.
Commercial	Land on which the primary activity is the commercial buying, selling, or trading of goods or services. Children and members of the public normally have free access to these lands.

Industrial — Land on which the primary activity is the production, manufacture, construction or storage of goods. Public access is restricted and children are not permitted continuous access or occupancy.

It is important to note that *current and intended future land use* governs the decision on the level of remediation to be performed at a site. The type of land use found adjacent to the contaminated site may also affect the remediation criteria to be achieved.

2.6.2 Chemical and Physical Properties of Petroleum Hydrocarbons

The physical and chemical properties of a contaminant determine to a large degree its mobility, fate and availability to receptors. For PHC in soils, behavior varies with the hydrocarbon source and composition, degree of processing (i.e. crude oil, blended or refined) and the extent of weathering caused by exposure to the environment. For this reason, environmental quality standards and guidelines subdivide PHCs into four fractions according to the number of carbon molecules in each hydrocarbon chain. This number is referred to as the PHC equivalent carbon number (ECN). These fractions include:

Fraction 1 (F1)[5] — ECN range from C6 to C10. It includes gasoline and represents the volatile fraction of most hydrocarbon mixtures. The F1 fraction consists of aromatic subfractions in the range C8 to C10, as well as aliphatic subfractions in the ranges of C6 to C8 and C8 to C10. The fraction is generally considered to be high in mobility, volatility and solubility and is considered to be the more toxic of the hydrocarbon fractions.

Fraction 2 (F2) — ECN range from C10 to C16. It includes kerosene, jet fuel and light fuel oils (i.e. No. 2 fuel oil, Arctic diesel) and represents the semi-volatile fraction of petroleum hydrocarbons. The F2 fraction is comprised of aromatics and aliphatic subfractions in the ranges C10 to C12 and C12 to C16.

Fraction 3 (F3) — ECN range from C16 to C34 and includes medium fuel oils (i.e. No. 4 fuel oil, Bunker B), heavy fuels oils (i.e. Bunker C) and lubricating and motor oils. It is comprised of both aromatics and aliphatics in the range C16 to C34.

Fraction 4 (F4) — ECN range from C34 to C50+. PHC within this range often make up a significant proportion of crude oils. The fraction is generally considered to be of low mobility, volatility and solubility.

2.6.3 Soil Properties and Texture

The ability of a contaminant to migrate through soil is influenced by the properties and texture of the soil. Many environmental quality standards and guidelines incorporate this by classifying soil as being either 'coarse' or 'fine'. The American Society for Testing and Materials defines *fine-grained soil* as having a grain size of less than 75 micrometers[6] (µm) while *course-grained soil* has a grain size greater than 75 µm. Table 1 further defines soil grain size using common terms.

[5] Some specific aromatic compounds found within the F1 fraction are managed separately from PHC. Benzene ("B") has been excluded because of its carcinogenic properties while toluene, ethylbenzene and xylene ("TEX") have been excluded because of the relatively long history of managing these compounds. Collectively these compounds are referred to as "BTEX".

[6] One micrometer (µm) is the same as one one-millionth of a meter.

Table 1. Soil Classification and Grain Size

			Grain Size Range (µm)
Coarse Grained Soil	**Gravel**	Coarse gravel	20000 – 63000
		Medium gravel	6300 – 20000
		Fine gravel	2000 - 6300
	Sand	Coarse sand	630 - 2000
		Medium sand	200 - 630
		Fine sand	63 - 200
Fine Grained Soil	**Silt**	Coarse silt	20 - 63
		Medium silt	6 - 20
		Fine silt	2 - 6
	Clay		Less than 2

2.6.4 Canada-Wide Standard for Petroleum Hydrocarbons in Soil

The Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CWS PHC) was developed through the Canadian Council of Ministers of the Environment. It was adopted by all federal, provincial and territorial governments, except Quebec, in 2001 and subsequently updated in 2008.

The CWS PHC is a numerical standard for petroleum hydrocarbon impacted surface soil and subsoil and is grounded in the science of risk assessment. It is a three-tiered framework which establishes reasonably conservative remediation criteria corresponding to the intended land use, nature of the petroleum hydrocarbon and soil texture characteristics of the site. They are considered to be generally protective of human and environmental health for the 'normal' activities associated with each land use.

The CWS PHC can be applied at any of three levels or 'Tiers': Tier 1 – generic numerical standards corresponding to four land use scenarios; Tier 2 – adjustments to Tier 1 levels based on site-specific considerations; and Tier 3 – site-specific risk management. Refer to section 2.7 *Establishment of Site-Specific Remediation Criteria* for information on each approach.

Tier 1 standards for PHC contamination of surface soil are summarized in Table 2[7]. The standards are based on the most sensitive exposure pathway and may be adopted as site-specific remediation criteria where site conditions, receptors and exposure pathways are similar to those assumed in the development of the standards. It is important to note that benzene, toluene, ethylbenzene and xylene, which are collectively referred to as BTEX, are managed separately from PHC. Numerical objectives for BTEX are summarized in Table A3.1 of Appendix 3.

[7] Although the Tier 1 standards were originally developed for remediation of 'surface soil', they may also be used for 'subsoil' as PHC contaminated subsoil has a lower level of risk associated with direct human contact, vapour inhalation and ecological soil contact. The Nunavut Environmental Protection Division must be consulted in all cases where PHC concentrations in 'subsoil' exceed Tier 1 standards.

Table 2. Tier 1 Levels for PHC for Surface Soils.

Land Use	Soil Texture	Fraction 1[a] (C6-C10)	Fraction 2[a] (>C10-C16)	Fraction 3[a] (>C16-C34)	Fraction 4[a] (>C34)
Agricultural/Wildland	Fine-grained soil	210 (170[b])	150	1300	5600
	Course-grained soil	30[c]	150	300	2800
Residential/Parkland	Fine-grained soil	210 (170[b])	150	1300	5600
	Course-grained soil	30[c]	150	300	2800
Commercial	Fine-grained soil	320 (170[b])	260 (230[b])	2500	6600
	Course-grained soil	320 (240[b])	260	1700	3300
Industrial	Fine-grained soil	320 (170[b])	260 (230[b])	2500	6600
	Course-grained soil	320 (240[b])	260	1700	3300

a = All values are expressed as milligrams per kilogram (mg/kg). Refer to additional definitions in Appendix 2.
b = Where applicable, for protection against contaminated groundwater discharge to an adjacent surface water body or for protection of potable groundwater.
c = Assumes contamination near a residence.

Where the most sensitive exposure pathway is not relevant to the site (i.e. contaminated groundwater discharge to an adjacent surface water body is unlikely or residences are not located nearby), the standards summarized in Table 1 may be substituted using the pathway-specific Tier 1 standards identified in Tables 3 and 4.

2.6.5 Canadian Environmental Quality Guidelines

Environmental Quality Guidelines (EQG) are generic numerical limits or narrative statements that are intended to maintain and protect a specified use of soil, water or sediment. An EQG does not take into account site-specific conditions.

Canadian Soil Quality Guidelines for the Protection of Environment and Human Health

Where contaminants are present in soil that are not addressed through the CWS PHC (i.e. BTEX, PCB, metals, PAHs), the *Canadian Soil Quality Guidelines (CSoilQG) for the Protection of Environment and Human Health* can be used as the basis for establishing site-specific remediation criteria. Developed by the Canadian Council of Ministers of the Environment, CSoilQG were developed using toxicological data to determine effects on key ecological and human receptors. Exposure from direct soil contact and ingestion, soil texture and the four primary land use categories are the major risk factor determinants. A summary of selected CSoilQG is provided in Table A3.1 of Appendix 3.

Canadian Water Quality Guidelines for the Protection of Aquatic Life

The *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CWQG) is intended to protect freshwater and marine life from the release of contaminants or changes to physical components (i.e. pH, temperature, and debris) from human activity. They are meant to protect all forms of aquatic life and aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term and provide a science-based benchmark for nationally consistent protection of aquatic life in Canada. A summary of selected CWQG is provided in Table A3.2 of Appendix 3.

Table 3. Pathway-Specific Tier 1 Levels for PHC for Fine-Grained Surface Soils.

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural/	Direct Contact (Ingestion + Dermal Contact)	12 000	6800	15 000	21 000
Wildland	Vapour Inhalation (indoor, basement)	710	3600	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	610	3100	NA	NA
	Protection of Potable Groundwater (GW)	170	230	NA	NA
	Protection of GW for Aquatic Life[a]	RES	RES	NA	NA
	Protection of GW for Livestock Watering	4200	10 000	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	1300	5600
	Eco Soil Ingestion	NC	NC	NC	NC
	Produce, Meat and Milk Ingestion	NC	NC	NC	NC
	Management Limit[b]	800	1000	3500	10 000
Residential/	Direct Contact (Ingestion + Dermal Contact)	12 000	6 800	15 000	21 000
Parkland	Vapour Inhalation (indoor, basement)	710	3600	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	610	3100	NA	NA
	Protection of Potable GW	170	230	NA	NA
	Protection of GW for Aquatic Life[a]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	1300	5600
	Produce Ingestion	NC	NC	NC	NC
	Management Limit[b]	800	1000	3500	10 000
Commercial	Direct Contact (Ingestion + Dermal Contact)	19 000	10 000	23 000	RES
	Vapour Inhalation (indoor)	4600	23 000	NA	NA
	Protection of Potable GW	170	230	NA	NA
	Protection of GW for Aquatic Life[a]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	2500	6600
	Offsite Migration	NA	NA	19 000	RES
	Management Limit[b]	800	1000	5000	10 000
Industrial	Direct Contact (Ingestion + Dermal Contact)	RES	RES	RES	RES
	Vapour Inhalation (indoor)	4600	23 000	NA	NA
	Protection of Potable GW	170	230	NA	NA
	Protection of GW for Aquatic Life[a]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	2500	6600
	Offsite Migration	NA	NA	19 000	RES
	Management Limit[b]	800	1000	5000	10 000

All values are expressed as milligrams per kilogram (mg/kg). Refer to additional definitions in Appendix 2.
NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
a = Assumes surface water body at 10 meters (horizontal) from site.
b = Includes additional considerations such as free phase formation, explosive hazards, and buried infrastructure effects.

Table 4. Pathway-Specific Tier 1 Levels for PHC for Course-Grained Surface Soils.

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural/ Wildland	Direct Contact (Ingestion + Dermal Contact)	12 000	6800	15 000	21 000
	Vapour Inhalation (indoor, basement)	40	190	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable Groundwater (GW)	240	320	NA	NA
	Protection of GW for Aquatic Life[a]	970	380	NA	NA
	Protection of GW for Livestock Watering	5300	14 000	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	300	2800
	Eco Soil Ingestion	NC	NC	NC	NC
	Produce, Meat and Milk Ingestion	NC	NC	NC	NC
	Management Limit[b]	700	1000	2500	10 000
Residential/ Parkland	Direct Contact (Ingestion + Dermal Contact)	12 000	6800	15 000	21 000
	Vapour Inhalation (indoor, basement)	40	190	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[a]	970	380	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	300	2800
	Produce Ingestion	NC	NC	NC	NC
	Management Limit[b]	700	1000	2500	10 000
Commercial	Direct Contact (Ingestion + Dermal Contact)	19 000	10 000	23 000	RES
	Vapour Inhalation (indoor)	320	1700	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[a]	970	380	NC	NC
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	230	260	1700	3300
	Offsite Migration	NA	NA	4300	RES
	Management Limit[b]	700	1000	3500	10 000
Industrial	Direct Contact (Ingestion + Dermal Contact)	RES	RES	RES	RES
	Vapour Inhalation (indoor)	320	1700	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[a]	970	380	NC	NC
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	1700	3300
	Offsite Migration	NA	NA	4300	RES
	Management Limit[b]	700	1000	3500	10 000

All values are expressed as milligrams per kilogram (mg/kg). Refer to additional definitions in Appendix 2.
NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
a = Assumes surface water body at 10 meters (horizontal) from site.
b = Includes additional considerations such as free phase formation, explosive hazards, and buried infrastructure effects.

Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

Contaminants released into surface water may partition into particulates and be deposited into the bed sediments where they accumulate over long periods of time. These sediments may ultimately act as long-term reservoirs of contaminants and impact aquatic organisms living in, or having direct contact with, sediments. The *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CSedQG) establish guidelines for assessing freshwater and marine sediment quality for a number of contaminants. A summary of selected CSedQG is provided in Table A3.3 of Appendix 3.

2.7 Establishment of Site-Specific Remediation Criteria and Objectives

Remediation Criteria are site-specific numerical limits or narrative statements relating to individual substances or chemicals which have been adopted for use during the decommissioning or remediation of a contaminated site. These criteria take into consideration the presence, concentration and nature of the contamination and relevant site conditions.

There are two basic approaches to establishing remediation criteria for a site. The process of applying environmental quality standards and guidelines to derive site-specific criteria is known as the *Guideline-Based Approach*. Using this approach, standards and guidelines can be adopted directly (Method 1) or be developed by modifying the standards and guidelines to take into account site-specific conditions (Method 2). The *Risk-Based Approach* involves the assessment of site-specific human health and ecological factors to establish remediation criteria and objectives (Method 3).

In general, the guideline-based approach requires fewer resources while providing a scientifically defensible basis for protection that is sufficiently flexible to account for certain site-specific factors. The risk-based approach can be more complex and costly, and is utilized when the guideline-based approach is not suitable for a site (i.e. the site is large and complex). Regardless of the chosen approach, the level of human health, worker safety and environmental protection provided does not change, only the manner in which the level of protection is achieved.

The land owner or site operator should consult the appropriate regulatory authorities before deciding upon which of the approaches and methods to take.

2.7.1 Guideline-Based Approach

Direct Adoption of Environmental Quality Standards and Guidelines

Using this method, the selected environmental quality standards and guidelines are adopted *de facto* as the remediation criteria. In most cases, the cleanup activities involve either reducing the concentration of contaminants to achieve the desired levels or removing and replacing the contaminated soil. Factors that may bear weight on the decision of whether to directly adopt the standards and guidelines as remediation criteria include cost, time, simplicity and other practical and technical considerations (i.e. cost of obtaining additional data to support method 2 or 3, risks associated with residual contamination, commitment to long-term management and monitoring).

Where the direct adoption of environmental quality standards and guidelines is neither practical nor cost effective, the land owner or site operator will need to look at modifying the selected standards and guidelines based on site-specific considerations.

Adoption of Modified Environmental Quality Standards and Guidelines

Environmental quality standards and guidelines may sometimes be modified and adopted for use as the site-specific remediation criteria. In these cases, the site conditions and use, available receptors and exposure pathways must differ only slightly from those assumed in the development of the standard or guideline. Where PHC is present in soil, the decision to undertake specific Tier 2 adjustments (refer to Tables 2 and 3) implies a commitment to increase the accuracy of information on site-specific factors, including exposure and risk estimates. Specific guidance on situations where modifications to the Tier 1 levels are appropriate, as well as details concerning implementation of the approach, is provided in the *Canada-Wide Standard for Petroleum Hydrocarbons in Soil User Guide (CCME 2008).*

The acceptability of a modified standards and guidelines approach is subject to review by the regulatory authorities. If the environmental impacts extend off-site, the land owner or site operator should also seek the acceptance of other affected parties.

2.7.2 Risk-Based Approach

The guideline-based approach may not always be suitable where site conditions are unique and exposure pathways, contaminants, receptors or other site characteristics differ significantly from the assumptions used to develop the environmental quality standards and guidelines. In these cases, a risk-based approach may be required to develop site-specific remediation criteria and objectives.

There are two basic types of risk assessment: human health risk and ecological risk. One or both of these may be required to ensure the protection of both humans and the environment.

Undertaking a risk-based approach involves a significant commitment of time and resources. It is likely that the land owner or site operator will need to hire a qualified consultant with the necessary technical and scientific expertise to perform the work. A contaminated site may be a candidate for the risk-based approach when there are:

- significant ecological concerns (i.e. critical or sensitive habitats for wildlife; rare, threatened or endangered species; parkland or ecological reserves; special hunting or trapping resources);
- unacceptable site-specific data gaps (i.e. exposure conditions are unpredictable or uncertain; lack of information about receptors; high degree of uncertainty about hazard levels); or
- special site characteristics (i.e. site is large or remote; contamination is complex; estimated cost of remediation is prohibitive; site conditions, receptors or exposure pathways differ significantly from those assumed in the development of the environmental quality standards and guidelines.

Specific guidance on designing and carrying out a human health and ecological risk assessment is beyond the scope of this document. Land owners or site operators wishing to proceed with a risk-based approach to site remediation are encouraged to contact the appropriate regulatory authorities and professionals competent in the field of risk assessment.

2.8 Development of a Remedial Action Plan

The remediation of a contaminated site can range from a simple, straightforward cleanup to a complex, costly project. Consideration of alternative remediation, treatment and disposal methods and careful

planning and accounting for public and community concerns will help to facilitate effective and efficient decommissioning and restoration of a contaminated site.

2.8.1 Identification and Evaluation of Remediation, Treatment and Disposal Methods

Selecting a method to clean up a contaminated site must be given careful consideration as there are many remediation, treatment and disposal technologies available for use on the market.

There are three general approaches to remediating a contaminated site:

In situ treatment	Contaminated material is treated in place on site without removal.
Ex situ, on-site treatment	Contaminated material is removed by excavation or pumping, treated on site or locally within the community and then replaced.
Ex situ, off-site treatment or disposal	Contaminated material is removed by excavation or pumping and transported out of the community for treatment or disposal at a licensed and approved treatment facility or secure regulated landfill.

Once the general approach has been chosen, all potential remediation technologies should be evaluated for their feasibility using the site-specific conditions identified in earlier investigations. The selected technologies should be practical and safe in addressing the contaminants of concern, cost effective, implementable with the resources that are available, able to effectively address the environmental and health effects and minimize impacts during implementation (i.e. construction, digging, hauling). In many cases, consultation with regulatory authorities may be necessary to ensure the overall strategy meets regulatory requirements.

Table 5 provides a brief description of a few remediation technologies used for treatment of soil contaminated with petroleum hydrocarbons[8].

In general, the *in situ* and *ex situ on-site* treatment approaches are the preferred approaches given the isolated and remote nature of Nunavut's communities and industrial sites. Those technologies that decontaminate soil and permit its re-use should be given priority. The re-use of treated material (i.e. soil, sand and gravel) potentially lowers the overall project costs, minimizes the environmental impacts of obtaining new fill material and conserves the available local fill material for other uses. Alternatively, the treated material can be set aside for other purposes providing that the level of treatment is consistent with the intended land use (i.e. soil treated to commercial and industrial standards may only be used on land designated for commercial and industrial use).

Any land owner or site operator wishing to dispose of or treat contaminated material at a community landfill must first obtain authorization and approval from the local community government.

Table 5. Selected Remediation Methods and Technologies for PHC in Soil

[8] Technical summaries are available on-line from a variety of sources including the USEPA Technology Innovation Office (www.clu-in.org), Groundwater Remediation Technologies Analysis Center (www.gwrtac.org) and the Ontario Centre for Environmental Technology Advancement (www.oceta.on.ca).

In Situ Methods and Treatments

Natural Attenuation

Natural attenuation relies on natural processes to clean up or attenuate PHC in soil. While it occurs at most sites naturally, the right conditions (i.e. warmth, oxygen and microorganisms) must be present for breakdown of the PHC to be quick enough or complete enough. *In situ* natural attenuation requires the land owner or site operator to 'risk manage and monitor' the site for many years and is generally not an acceptable option for site remediation.

Soil Vapour Extraction

Soil vapor extraction is used to remediate unsaturated soil. A vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semi-volatile PHC contaminants from the soil. Vapour extraction is usually performed *in situ* however, in some cases, it can be used as an *ex situ* technology.

Thermal Treatment

Many different techniques can be used to apply heat to soil *in situ* (i.e. electrical resistance heating, radio frequency heating, thermal conduction or injection of hot water, hot air, or steam). As the PHC change into gases, its mobility increases and vapours can be extracted using soil vapour extraction. *In situ* thermal treatment generally requires longer time periods than *ex situ* thermal treatment and there is less certainty about the uniformity of treatment.

Ex Situ Methods and Treatments

Natural Attenuation

Similar to *in situ* natural attenuation, *ex situ* natural attenuation relies on natural processes to break down the PHC in soil. Unlike the *in situ* method however, the soil is excavated, moved and placed on an impermeable liner. This allows the soil to be warmed by the sun and periodically 'turned over' using local equipment which enhances natural biodegradation and volatilization processes. Precipitation runoff from an *ex situ* natural attenuation treatment site must be controlled to ensure the PHC does not migrate off the site.

Bioremediation

Bioremediation uses microorganisms to degrade PHC in soil. Microorganisms break down the carbon molecules by using them as an energy source. To stimulate and enhance microbial activity, microorganisms (bioaugmentation) or amendments such as air and fertilizers or other nutrients (biostimulation) can be added. While bioremediation is usually applied *ex situ*, it may be applied *in situ* in limited cases.

Soil Washing

Contaminants absorbed onto fine soil particles are separated from bulk soil in a water-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, or chelating agent or by adjustment of pH to help remove organics and heavy metals. Soils and wash water are mixed *ex situ* in a tank or other treatment unit and the soil fractions later separated using gravity settling.

Thermal Treatment

Ex situ thermal treatment involves the destruction of PHC through exposure to high temperatures in treatment cells or combustion chambers. The main advantage of *ex situ* thermal treatment (as compared to *in situ*) is that it generally requires shorter time periods and there is more certainty about the uniformity of treatment. *Ex situ* thermal treatment also kills the indigenous microorganisms rendering the soil sterile

Solvent Extraction

Solvent extraction uses an organic solvent as an extractant to separate PHC and other organic contaminants from soil. The organic solvent is mixed with soil in an extraction unit and the extracted solution is then passed through a separator where the contaminants and extractant are separated from the soil.

2.8.2 Preparation of a Remedial Action Plan

Once the remediation criteria and preferred remedial technologies have been determined, a Remedial Action Plan can be developed which reflects the intended remediation approach. Where practical, the plan should favour permanent remediation solutions, and not solutions that require long-term management and monitoring. A "do nothing" approach is not acceptable.

The Remedial Action Plan should provide sufficient detail so as to identify the current site conditions, proposed remediation technologies and approaches, targeted remediation criteria and objectives and should include an implementation schedule. More specifically, the plan should:

- include names and contact information for all key personnel, consultants and contractors;
- summarize all data collected during the site investigations;
- identify contaminants of concern and the media (i.e. soil, water) and receptors affected;
- identify the remediation criteria and objectives and methods by which they have been derived;
- identify, quantify and characterize the materials to be treated, removed and disposed;
- summarize the remedial options evaluated and methods used to select the preferred strategy;
- describe the selected remediation, treatment and disposal method and its technical feasibility;
- detail an implementation plan, including an implementation schedule;
- discuss measures to minimize fugitive air emissions, surface water control, and worker health and safety concerns;
- identify the fate of residual contaminants that may remain on-site following remediation; and
- identify remedial verification and, if required, long-term monitoring plans.

The Remedial Action Plan is subject to review by regulatory authorities. It should be submitted to authorities several months before the intended mobilization date in order to ensure all regulatory requirements are being met and avoid unnecessary and costly delays. Depending upon the complexity and size of the remediation project, the land owner or site operator may also want to have an independent review of the plan conducted prior to submitting it to regulatory authorities. A copy of the independent review should be submitted along with the plan.

A Worker Health and Safety Plan may also need to be developed and submitted to the Workers' Safety and Compensation Commission.

2.8.3 Public Involvement and Community Relations

The awareness of environmental issues among community governments and the public has increased significantly in recent years. Property owners or site operators should consider developing a Community Information Program early in the planning process to help guide their relationship with these important stakeholders. In addition to informing the public of planned or ongoing activities, the Community Information Program should facilitate opportunities for the public to comment on and provide input to technical decisions of public interest (i.e. noise, traffic and public safety). In this way, a consensus can be achieved which will help to facilitate successful completion of the proposed work and avoid future potential conflict.

2.9 Implementation of a Remedial Action Plan

The property owner or site operator can begin to implement the Remedial Action Plan once all necessary licenses, permits and other approvals have been obtained. All activities should be undertaken in a way that minimizes disruption of nearby residents. Periodic activity and monitoring reports must be provided in accordance with the Remedial Action Plan and regulatory approvals. Regulatory authorities must be advised immediately of any unanticipated occurrences or if on-site activities deviate significantly from the approved Remedial Action Plan. In these cases, the regulatory authorities will assess the significance of this new information and advise the owner or operator accordingly.

2.9.1 Documentation and Recording Keeping

It is important to establish and maintain an organized and comprehensive documentation and record keeping system during the course of remediating a contaminated site. This information provides an account of activities carried out and supports decisions affecting any changes to the Remedial Action Plan. There are many ways to document this information including daily, weekly and monthly reports, sample logs and analytical reports. The Remedial Action Plan should clearly establish a chain of responsibilities for maintaining this important documentation.

2.9.2 Site Control and Access

The safety of the public and workers is critical. Controlling access to the contaminated site during the investigation and remediation stages will help to minimize exposure of the public, workers and unaffected adjacent areas to contamination, as well as protect the public from site hazards and prevent vandalism. The remedial activities and site conditions will influence the types and extent of necessary measures. For small short-term projects, temporary snow fencing and hazard tape may be all that is required. For large long-term projects, access may need to be controlled through permanent chain-link fencing and full-time site security.

2.9.3 Changing Site Conditions

Unanticipated developments can occur during any remediation project. As an example, highly contaminated areas or 'hot spots' can be discovered, contaminant concentrations can exceed a treatment system's design specification or air monitoring can identify unexpected fugitive emissions. The Remedial Action Plan must be flexible enough to enable changes to be made and the rationale for any changes attached to all copies of the plan. Any planned revisions should be submitted to the regulatory authorities for review.

2.10 Confirmatory Testing and Analysis

Prior to demobilizing equipment from the site, confirmatory testing and analysis should be undertaken to demonstrate the contamination has been successfully removed or stabilized and the remediation objectives achieved. Test results of soil, groundwater and surface water remaining on site are compared to the remediation criteria and original local background samples from areas unaffected by the contamination. Where the confirmatory testing indicates that the remediation criteria and objectives have not been achieved, further remediation may be necessary.

2.11 Completion Reporting and Closure Confirmation

Once the land owner or site operator is satisfied that the contamination has been removed or stabilized and the remediation criteria and objectives achieved, a completion report, sometimes referred to as a closure report, should be prepared. The report generally includes a description of all activities carried out during the remediation, methods and technologies used, quantity of contaminated material treated or disposed and all drawings, records and analytical data generated. The report should be submitted to regulatory authorities in a timely manner for review and final acceptance. A copy of the report should also be retained by the land owner or site operator as a permanent record of the remedial activities.

Where the regulatory authorities are satisfied the remediation criteria and objectives have been achieved, the agencies may issue a letter advising the land owner or site operator that no further remedial action is required. This would normally enable unrestricted future use of the land within the land use designation and is referred to as *unconditional closure*. Where containment and treatment facilities or residual contamination remain on site, or where a risk-management approach has been taken, regulatory authorities may place land use controls and other restrictions on the site to ensure the risk to human health, safety and environment does not increase. This is referred to as *conditional closure*.

2.12 Long-Term Monitoring

The land owner or site operator may be required to undertake long-term monitoring as a condition of regulatory authorities providing conditional closure. Long-term monitoring programs should always be developed in consultation with regulatory authorities and may consist of soil, groundwater, surface water and air sampling and analysis; and periodic inspections of on-site containment and treatment facilities, stabilized structures and restricted site access measures. The land owner or site manager should anticipate having to implement a long-term monitoring program wherever a risk-management approach to site remediation is undertaken.

Conclusion

A contaminated site is broadly defined as a location at which soil, water or sediment have levels of contaminants above the benchmark criteria and that pose an unacceptable risk to the health and safety of people and the environment. They are not uncommon in Nunavut and can pose a significant risk to human health, safety and the environment. Contaminated sites can range in location and severity from a slow drip or leakage from a residential home heating oil tank to a major discharge of fuel oil or gasoline from a community or industrial bulk storage facility.

The *Environmental Guideline for the Management of Contaminated Sites* focuses on the management of petroleum hydrocarbon contaminated soil, water and sediment. Where sites are contaminated with other substances or chemicals, the principles and methods described in this Guideline may still be applied. The guideline is intended to assist land owners and site operators in establishing a consistent approach to managing contaminated sites in Nunavut. It provides a general step-by-step overview of the process. This includes the identification and characterization (i.e. assessment) of the site, determination of site-specific remediation criteria using a guideline-based or risk-based approach, general overview of remediation methods and technologies, development and implementation of a Remedial Action Plan, site closure and the identification of long-term monitoring requirements.

Familiarity with the Guideline does not replace the need for the landowner, site operator or person in charge, management or control of a contaminated site to comply with all applicable federal and territorial legislation and community by-laws. The management of these sites may also be controlled through permits and licenses issued by Nunavut's co-management boards, Designated Inuit Organizations, Aboriginal Affairs and Northern Development Canada and other regulatory authorities. These permits and licenses must be complied with at all times.

For additional information on the remediation of contaminated sites, or to obtain a complete listing of guidelines, go to the Department of Environment web site or contact the Department at:

Environmental Protection Division
Department of Environment
Government of Nunavut
Inuksugait Plaza, P.O. Box 1000, Station 1360
Iqaluit, Nunavut X0A 0H0

Telephone: (867) 975-7729
Fax: (867) 975-7739
Email: EnvironmentalProtection@gov.nu.ca
Website: http://env.gov.nu.ca/programareas/environmentprotection

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APPENDIX 1 – EXCERPTS FROM THE *ENVIRONMENTAL PROTECTION ACT*

The following are excerpts from the *Environmental Protection Act*

1. "Contaminant" means any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment,
   (a) endangers the health, safety or welfare of persons,
   (b) interferes or is likely to interfere with normal enjoyment of life or property,
   (c) endangers the health of animal life, or
   (d) causes or is likely to cause damage to plant life or to property;

   "Discharge" includes, but not so as to limit the meaning, any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping;

   "Environment" means the components of the Earth and includes
   (a) air, land and water,
   (b) all layers of the atmosphere,
   (c) all organic and inorganic matter and living organisms, and
   (d) the interacting natural systems that include components referred to in paragraphs (a) to (c).

   "Inspector" means a person appointed under subsection 3(2) and includes the Chief Environmental Protection Officer.

2.2 The Minister may
   (a) establish, operate and maintain stations to monitor the quality of the environment in the Territories;
   (b) conduct research studies, conferences and training programs relating to contaminants and to the preservation, protection or enhancement of the environment;
   (c) develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment;
   (d) collect, publish and distribute information relating to contaminants and to the preservation, protection or enhancement of the environment:

3. (1) The Minister shall appoint a Chief Environmental Protection Officer who shall administer and enforce this Act and the regulations.

   (2) The Chief Environmental Protection Officer may appoint inspectors and shall specify in the appointment the powers that may be exercised and the duties that may be performed by the inspector under this Act and regulations.

5. (1) Subject to subsection (3), no person shall discharge or permit the discharge of a contaminant into the environment.

   (3) Subsection (1) does not apply where the person who discharged the contaminant or permitted the discharge of the contaminant establishes that
   (a) the discharge is authorized by this Act or the regulations or by an order issued under this Act or the regulations;
   (b) the contaminant has been used solely for domestic purposes and was discharged from within a dwelling house;
   (c) the contaminant was discharged from the exhaust system of a vehicle;

(d) the discharge of the contaminant resulted from the burning of leaves, foliage, wood, crops or stubble for domestic or agricultural purposes;
(e) the discharge of the contaminant resulted from burning for land clearing or land grading;
(f) the discharge of the contaminant resulted from a fire set by a public official for habitat management of silviculture purposes;
(g) the contaminant was discharged for the purposes of combating a forest fire;
(h) the contaminant is a soil particle or grit discharged in the course of agriculture or horticulture; or
(i) the contaminant is a pesticide classified and labelled as "domestic" under the *Pest Control Products Regulations* (Canada).

(4) The exceptions set out in subsection (3) do not apply where a person discharges a contaminant that the inspector has reasonable grounds to believe is not usually associated with a discharge from the excepted activity.

5.1. Where a discharge of a contaminant into the environment in contravention of this Act or the regulations or the provisions of a permit or license issued under this Act or the regulations occurs or a reasonable likelihood of such a discharge exists, every person causing or contributing to the discharge or increasing the likelihood of such a discharge, and the owner or the person in charge, management or control of the contaminant before its discharge or likely discharge, shall immediately:
(a) subject to any regulations, report the discharge or likely discharge to the person or office designated by the regulations;
(b) take all reasonable measures consistent with public safety to stop the discharge, repair any damage caused by the discharge and prevent or eliminate any danger to life, health, property or the environment that results or may be reasonably expected to result from the discharge or likely discharge; and
(c) make a reasonable effort to notify every member of the public who may be adversely affected by the discharge or likely discharge.

6. (1) Where an inspector believes on reasonable grounds that a discharge of a contaminant in contravention of this Act or the regulations or a provision of a permit or license issued under this Act or the regulations has occurred or is occurring, the inspector may issue an order requiring any person causing or contributing to the discharge or the owner or the person in charge, management or control of the contaminant to stop the discharge by the date named in the order.

7. (1) Notwithstanding section 6, where a person discharges or permits the discharge of a contaminant into the environment, an inspector may order that person to repair or remedy any injury or damage to the environment that results from the discharge.

(2) Where a person fails or neglects to repair or remedy any injury or damage to the environment in accordance with an order made under subsection (1) or where immediate remedial measures are required to protect the environment, the Chief Environmental Protection Officer may cause to be carried out the measures that he or she considers necessary to repair or remedy an injury or damage to the environment that results from any discharge.

APPENDIX 2 – ADDITIONAL DEFINITIONS OF KEY TERMS

Accreditation	Formal recognition of the competence of an environmental analytical laboratory to carry out specified tests. Formal recognition is based on an evaluation of laboratory capability and performance. Site inspections are utilized in the evaluation of capability.
Adverse Effect	An undesirable or harmful effect to an organism, indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.
Assess or Assessment	Investigations, monitoring, testing and other information-gathering activities to identify: (1) the existence, source, nature and extent of contamination resulting from the release of a hazardous material or chemical substance into the environment; and (2) the extent of risk to public health, safety, welfare and the environment. The term also includes studies, services, and investigations to plan, manage, decommission and clean up a contaminated site.
Background Area	An area not influenced by contaminants.
Background Samples	Samples without the chemicals of interest that are carried through all steps of the analytical procedure. They are used to provide a reference for determining whether test results are significantly higher than "unpolluted" samples which contain "zero", low, or acceptable levels of the chemicals. All samples, sample containers, reagents, glassware, preparations and instrumental analyses are included in the analysis of background samples.
Blank	The measured value obtained when a specified component of a sample is not present.
Borehole	A hole drilled into the earth and into which casings or screens can be installed to construct a well.
Clean up	The removal of a chemical substance or hazardous material from the environment to prevent, minimize or mitigate damage to public health or safety and the environment that may result from the presence of the substance or material. A clean up is generally carried out to achieve specified remediation criteria or objectives.

Concentration	The amount of chemical or substance in the environment. Concentration is typically expressed as milligrams per liter (mg/L) or micrograms per liter (µg/L) in water, milligrams per kilogram (mg/kg) in soil and food and micrograms per cubic meter (µg/m^3) in air. Concentrations may also be expressed as parts per million (ppm) or parts per billion (ppb). 1 mg/liter = 1 ppm or 1000 ppb 1 µg/liter = 1 ppb 1 mg/kg = 1 ppm or 1000 ppb
Criteria	Numerical standards that are established for chemical substances in soil, water, sediment or air to determine the acceptability of a site for a specific intended land use.
Environmental Analytical Laboratory	A laboratory engaged in the physical, chemical or biological measurement of the receiving environment or discharges to the receiving environment.
Groundwater	All subsurface water that occurs beneath the water table in rocks and geologic formations that are fully saturated.
Hazardous Material	Material that, because of its quality, concentration, chemical composition or corrosive, flammable, reactive, toxic, infectious or radioactive characteristics, constitutes a present or potential threat to human health and safety or the environment when improperly stored, treated, transported, disposed of, used or otherwise managed.
Headspace	The empty volume in a container between the cap and the solid or liquid level of the sample.
Migration	The movement of chemicals, bacteria and gases in flowing water or vapour in the subsurface.
Monitoring	The periodic or routine (i.e. daily, weekly, monthly, quarterly) checking and measurement of certain biological or chemical variables, or the collection and testing of soil, water, sediment or air samples for hazardous materials or toxicity.
Monitoring Well	A well that is used to extract groundwater for physical, chemical or biological testing, or to measure water levels.
Objective	A numerical limit or narrative statement that has been established to protect and maintain a specified use of water, sediment or soil at a particular site by taking into account site-specific conditions. Objectives may be adopted directly as remediation criteria or modified to account for site-specific conditions.

Quality Assurance/Quality Control (QA/QC)	Procedures and controls designed to monitor the conduct of a study to ensure the quality of the data and the integrity of the study are maintained.
Receptor	A person or organism subjected to chemical exposure or an ecosystem component that is, or may be, adversely affected by a pollutant or other stress emanating from a contaminated site. Receptors may include biological or abiotic (i.e. air or water quality) components.
Risk	A measure of both the severity of effects arising from exposure to a substance and the probability of its occurrence.
Risk Assessment	A procedure designed to determine the qualitative aspects of hazard identification and usually a quantitative determination of the level of risk.
Screening	Rapid analysis to determine whether further detailed testing, analysis or remediation is warranted.
Site-Specific Remediation Criteria	Numerical targets established for a specific site to be met through implementation of a Remedial Action Plan and, if appropriate, long-term site management.
Subsoil	Soil which is 1.5 meters (approximately 5 feet) or deeper from the surface.
Surface Soil	Soil which is less than 1.5 meters (approximately 5 feet) from the surface.
Surface Water	Natural water bodies, such as rivers, streams, brooks, lakes and oceans.
Test Pit	A shallow pit made to characterize surface soil and subsoil.

APPENDIX 3 – CANADIAN ENVIRONMENTAL QUALITY OBJECTIVES

Table A3.1 Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.

Substance	Land Use and Soil Texture							
	Agricultural/ Wildland		Residential/ Parkland		Commercial		Industrial	
	Course	Fine	Course	Fine	Course	Fine	Course	Fine
Arsenic (inorganic)	12		12		12		12	
Barium	750		500		2000		2000	
Benzene								
Surface[a]	0.03	0.0068	0.03	0.0068	0.03	0.0068	0.03	0.0068
Subsoil[a]	0.03	0.0068	0.03	0.0068	0.03	0.0068	0.03	0.0068
Surface[b]	0.0095	0.0068	0.0095	0.0068	0.03	0.0068	0.03	0.0068
Subsoil[b]	0.011	0.0068	0.011	0.0068	0.03	0.0068	0.03	0.0068
Cadmium	1.4		10		22		22	
Chromium								
Total chromium	64		64		87		87	
Hexavalent chromium (IV)	0.4		0.4		1.4		1.4	
Trivalent chromium (III)	No Data		No Data		No Data		No Data	
Copper	63		63		91		91	
Cyanide (free)	0.9		0.9		8.0		8.0	
DDT (total)	0.7[c]		0.7[c]		12[c]		12[c]	
Ethylbenzene								
Surface	0.082	0.018	0.082	0.018	0.082	0.018	0.082	0.018
Subsoil	0.082	0.018	0.082	0.018	0.082	0.018	0.082	0.018
Ethylene glycol	960		960		960		960	
Lead	70		140		260		600	
Mercury (inorganic)	6.6		6.6		24		50	
Nickel	50		50		50		50	
Nonylphenol (and its ethyloxylates)	5.7		5.7		14		14	
Pentachlorophenol	7.6		7.6		7.6		7.6	
Phenol	3.8		3.8		3.8		3.8	
Polychlorinated biphenyls (PCB)	0.5[c]		1.3[c]		33[c]		33[c]	
Polychlorinated di-benzo-p-dioxins/dibenzofurans (PCDD/Fs)	4 ng TEQ/kg[c]		4 ng TEQ/kg[c]		4 ng TEQ/kg[c]		4 ng TEQ/kg[c]	
Propylene glycol	Insuff Info		Insuff Info		Insuff Info		Insuff Info	
Selenium	1		1		2.9		2.9	
Tetrachloromethane	0.1		5		50		50	
Thallium	1		1		1		1	
Toluene								
Surface	0.37	0.08	0.37	0.08	0.37	0.08	0.37	0.08
Subsoil	0.37	0.08	0.37	0.08	0.37	0.08	0.37	0.08
Trichloromethane (chloroform)	0.1		5		50		50	
Uranium	23		23		33		300	
Vanadium	130		130		130		130	
Xylenes								
Surface	11	2.4	11	2.4	11	2.4	11	2.4
Subsoil	11	2.4	11	2.4	11	2.4	11	2.4
Zinc	200		200		360		360	

All values in Table A3.1 are provided in milligrams per kilogram (mg/kg) unless otherwise indicated. Refer to additional definitions in Appendix 2.

Table Notes

[a] 10^{-5} incremental risk.

[b] 10^{-6} incremental risk.

[c] Although a CSoilQG exists for PCBs, PCDDs and PCDFs, these substances meet the criteria for track 1 substances under the national CCME Policy for the Management of Toxic Substances (persistent, bioaccumulative, primarily the result of human activity, and CEPA-toxic) and should be subject to virtual elimination strategies.

Table A3.1 presents numerical guidelines for selected substances only. Users are advised to consult the complete series of CSoilQGs, introductory texts, factsheets and protocols for specific information and implementation guidance. The series may be downloaded at http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html.

Table A3.2 Canadian Water Quality Guidelines for the Protection of Aquatic Life.

	Freshwater		Marine	
Substance	**Short Term**	**Long Term**	**Short Term**	**Long Term**
Arsenic (inorganic)	No Data	5	No Data	12.5
Barium	No Guideline has been developed			
Benzene	No Data	370	No Data	110
Cadmium	1	0.09	NRG	0.12
Chromium				
Total chromium	No Guideline has been developed			
Hexavalent chromium (IV)	No Data	1	No Data	1.5
Trivalent chromium (III)	No Data	8.9	No Data	56
Copper	No Data	Equation[a]	No Data	No Data
Cyanide (free)	No Data	5	No Data	No Data
DDT (total)	Virtual Elimination[b]	Virtual Elimination[b]	No Data	No Data
Ethylbenzene	No Data	90	No Data	25
Ethylene glycol	No Data	192 000	No Data	Insuff Info
Lead	No Data	Equation[a]	No Data	No Data
Mercury (inorganic)	No Data	0.026	No Data	0.016
Nickel	No Data	Equation[a]	No Data	No Data
Nonylphenol (and its ethyloxylates)	No Data	1	No Data	0.7
Pentachlorophenol	No Data	0.5	No Data	No Data
Phenol	No Data	4	No Data	No Data
Polychlorinated biphenyls (PCB)	Virtual Elimination[b]	Virtual Elimination[b]	Virtual Elimination[b]	Virtual Elimination[b]
Polychlorinated di-benzo-p-dioxins/dibenzofurans (PCDD/Fs)	Virtual Elimination[b]	Virtual Elimination[b]	Virtual Elimination[b]	Virtual Elimination[b]
Propylene glycol	No Data	500 000	No Data	Insuff Info
Selenium	No Data	1	No Data	No Data
Tetrachloromethane	No Data	13.3	No Data	Insuff Info
Thallium	No Data	0.8	No Data	No Data
Toluene	No Data	2	No Data	215
Trichloromethane (chloroform)	No Data	1.8	No Data	Insuff Info
Uranium	33	15	NRG	NRG
Vanadium	No Guideline has been developed			
Xylenes	No Guideline has been developed			
Zinc	No Data	30	No Data	No Data

All values in Table A3.2 are provided in micrograms per liter (µg/L). Refer to additional definitions in Appendix 2.

Table Notes

[a] The CWQG for copper, lead and nickel are related to water hardness (as $CaCO_3$). Refer to the specific Guideline Protocols.

[b] Although no CWQG exists for DDT, PCB, PCDD and PCDF, these substance meet the criteria for track 1 substances under the national CCME Policy for the Management of Toxic Substances (persistent, bioaccumulative, primarily the result of human activity, and CEPA-toxic) and should be subject to virtual elimination strategies.

Table A3.2 presents numerical guidelines for selected substances only. Although guidelines have not been developed for each of the listed substances, these substances have been included for comparison purposes with Tables A3.1 and A3.3. Users are advised to consult the complete series of CWQGs, introductory texts, factsheets and protocols for specific information and implementation guidance. The series may be downloaded at http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html.

Table A3.3 Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

Substance	Freshwater		Marine	
	Interim Sediment Quality Guideline (ISQG)	Probable Effect Level (PEL)	Interim Sediment Quality Guideline (ISQG)	Probable Effect Level (PEL)
Arsenic (inorganic)	5.9	17	7.24	41.6
Barium	No Guideline has been developed			
Benzene	No Guideline has been developed			
Cadmium	0.6	3.5	0.7	4.2
Chromium				
Total chromium	37.3	90	52.3	160
Hexavalent chromium (IV)	No Guideline has been developed			
Trivalent chromium (III)	No Guideline has been developed			
Copper	35.7	197	18.7	108
Cyanide (free)	No Guideline has been developed			
DDT (total)	0.00119	0.00477	0.00119	0.00477
Ethylbenzene	No Guideline has been developed			
Ethylene glycol	No Guideline has been developed			
Lead	35	91.3	30.2	112
Mercury (inorganic)	0.17	0.486	0.13	0.7
Nickel	No Guideline has been developed			
Nonylphenol (and its ethyloxylates)	1.4	No Data	1	No Data
Pentachlorophenol	No Guideline has been developed			
Phenol	No Guideline has been developed			
Polychlorinated biphenyls (PCB)	0.0341[a]	0.277[a]	0.0215[a]	0.189[a]
Polychlorinated di-benzo-p-dioxins/dibenzofurans (PCDD/Fs)	0.85 ng TEQ/kg[a]	21.5 ng TEQ/kg[a]	0.85 ng TEQ/kg[a]	21.5 ng TEQ/kg[a]
Propylene glycol	No Guideline has been developed			
Selenium	No Guideline has been developed			
Tetrachloromethane	No Guideline has been developed			
Thallium	No Guideline has been developed			
Toluene	No Guideline has been developed			
Trichloromethane (chloroform)	No Guideline has been developed			
Uranium	No Guideline has been developed			
Vanadium	No Guideline has been developed			
Xylenes	No Guideline has been developed			
Zinc	123	315	124	271

All values in Table A3.3 are provided in milligrams per kilogram dry weight (mg/kg) unless otherwise indicated. Refer to additional definitions in Appendix 2.

Table Note

[a] Although a CSedQG exists for PCBs, PCDDs and PCDFs, these substances meet the criteria for track 1 substances under the national CCME Policy for the Management of Toxic Substances (persistent, bioaccumulative, primarily the result of human activity, and CEPA-toxic) and should be subject to virtual elimination strategies.

Table A3.3 presents numerical guidelines for selected substances only. Although guidelines have not been developed for each of the listed substances, these substances have been included for comparison purposes with Tables A3.1 and A3.2. Users are advised to consult the complete series of CSedQGs, introductory texts, factsheets and protocols for specific information and implementation guidance. The series may be downloaded at http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html.

APPENDIX 4 - TRANSPORTATION OF PHC AND OTHER CONTAMINATED SOIL

Hazardous waste must be transported in accordance with the appropriate transport authority. In Nunavut, the transportation of hazardous waste by road is administered by the Department of Economic Development and Transportation under the *Transportation of Dangerous Goods Act* and Regulations. Transport by air must conform to the *International Air Transport Association* (IATA) *Dangerous Goods Regulations* and *International Civil Aviation Organization* (ICAO) *Technical Instructions*. Transport by marine must conform to the *International Marine Dangerous Goods Code*. Further information on transporting hazardous waste by air or marine can be obtained by contacting Transport Canada or by referring to the appropriate Transport Authority.

Soil contaminated with PHC is classified as either a Class 4 Flammable Solid or Class 9 Miscellaneous Waste under the *Transportation of Dangerous Goods Act* and Regulations and its classification, packaging, labeling and placarding while being transported must conform to specific requirements. Schedule I of the Regulations classify soil contaminated with PHC as follows:

Shipping Name:	WASTE SOLIDS CONTAINING FLAMMABLE LIQUID, N.O.S. Classification: 4.1 Product Identification Number: UN3175 Packing Group: II
Shipping Name:	WASTE ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. Classification: 9 Product Identification Number: UN3077 Packing Group: III

Land owners and site operators should refer to Schedule 1 of the *Transportation of Dangerous Goods Regulations* for the classification of soil contaminated with other hazardous substances.

Under the federal *Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations,* no person may transport hazardous waste for the purpose of disposal or recycling in a quantity greater than five kilograms or five liters unless it is accompanied by a completed manifest. Manifest forms provide detailed information on the types and amounts of waste shipped; a record of the parties involved; information on the storage, treatment or disposal of the waste; and confirmation that the waste has reached its final destination. Forms are available from the Nunavut Department of Environment and completion instructions are included on the reverse side of each manifest. Additional information on manifesting can be obtained by referring to the *Environmental Guideline for the General Management of Hazardous Waste*.

Hazardous waste generators, carriers and receivers must be registered with the Nunavut Department of Environment. A unique registration number is assigned to each registrant which enables completion of the manifest document. Copies of registration forms are available at http://env.gov.nu.ca/programareas/environmentprotection/forms-applications or by contacting Nunavut's Department of Environment. Additional information on the registration process can be obtained by referring to the *Environmental Guideline for the General Management of Hazardous Waste*.

A listing of hazardous waste carriers, receivers and management facilities registered to operate in Nunavut is available by contacting the Nunavut Department of Environment.

APPENDIX 5 – GOVERNMENT AND OTHER CONTACTS

Government of Nunavut

NWT/Nunavut 24-Hour Spill Report Line
Phone: (867) 920-8130

Environmental Protection Division
Department of Environment
Inuksugait Plaza
P.O. Box 1000, Station 1360
Iqaluit, Nunavut X0A 0H0
Phone: (867) 975-7729

Motor Vehicles Division
Department of Economic Development and Transportation
P.O. Box 10
Gjoa Haven, Nunavut X0B 1J0
Phone: (867) 360-4615

Workers' Safety and Compensation Commission
Qamutiq Building, 2nd Floor
611 Queen Elizabeth Way
P.O. Box 669
Iqaluit, Nunavut X0A 0H0
Phone: 1-877-404-4407

Department of Community and Government Services
P.O. Box 1000, Station 700
4th Floor, W.G. Brown Building
Iqaluit, Nunavut X0A 0H0
Phone: (867) 975-5400

Office of Chief Medical Officer of Health
Department of Health
P.O. Box 1000, Station 1000
Iqaluit, Nunavut X0A 0H0
Phone: (867) 975-5743

Government of Canada

Aboriginal Affairs and Northern Development Canada
969 Qimugjuk Building, 2nd Floor
P.O. Box 2200
Iqaluit, Nunavut X0A 0H0
Phone: (867) 975-4500

Environment Canada (NWT and Nunavut)
5019 52nd Street
P.O. Box 2310
Yellowknife, Northwest Territories X1A 2P7
Phone: (867) 669-4730

Transport Canada, Northern and Prairie Region
P.O. Box 8550
344 Edmonton Street
Winnipeg, Manitoba R3C 1P6
Phone: 1-888-463-0521

Other Contacts

Canadian Council of Ministers of the Environment[9]
123 Main Street, Suite 360
Winnipeg, Manitoba R3C 1A3
Phone: (204) 948-2090
Website: http://www.ccme.ca

Canadian Association for Environmental Analytical Laboratories[10]
300-1565 Carling Avenue
Ottawa, Ontario K1Z 8R1
Phone: (613) 233-5300
Website: http://www.caeal.ca/

Canadian Standards Association[11]
5060 Spectrum Way
Mississauga, Ontario L4W 5N6
Phone: (416) 747-4000
Website: http://www.csa.ca

[9] CCME works to promote effective intergovernmental cooperation and coordinated approaches to interjurisdictional issues such as air pollution and toxic chemicals. Under the auspices of CCME, the federal, provincial and territorial ministers of environment collectively establish nationally consistent environmental standards, strategies and objectives so as to achieve a high level of environmental quality across the country.

[10] CAEAL is a not-for-profit organization formed in 1989 dedicated to raising the level of competency, consistency, capability, and communication within environmental testing laboratories in Canada. Membership in CAEAL is open to individuals, institutions, user groups, consultants, industrial organizations, regulatory agencies, materials and laboratory equipment suppliers and others interested in the work being carried out in environmental analytical laboratories.

[11] CSA is a not-for-profit membership-based association serving business, industry, government and consumers in Canada and the global marketplace. As an organization, CSA works to develop standards that address a wide variety of needs, such as enhancing public health and safety, occupational health and safety and the environment.